Halocarbons from anthropogenic and natural sources in the Macaronesia region (future research)

Cape Verde: A natural laboratory for investigating the cycling of radiatively and chemically active trace gases between the surface ocean and the tropical atmosphere

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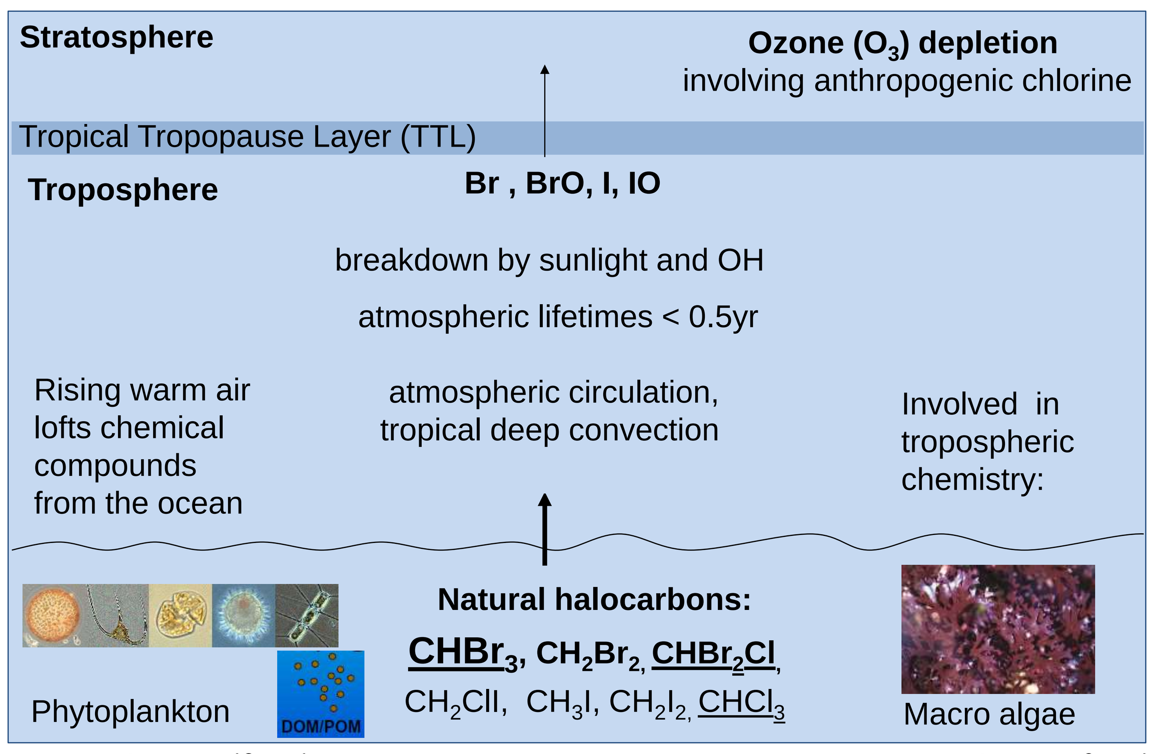
Natural and anthropoganic halocarbons from the tropics contribute to global ozone depletion



picomolar (10^{-12}) L^{-1} nanomolar (10^{-9}) L^{-1}

\+

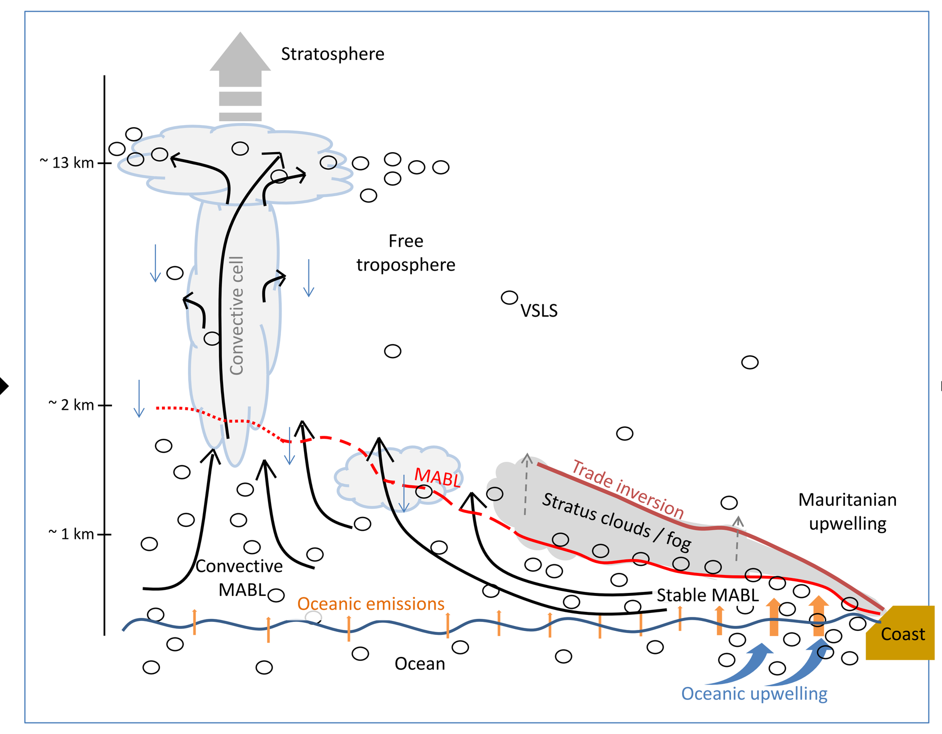
All disinfection of water, cooling water in coastal power plants, waste water, recreational water, ships ballast water, in desalination plants, …adds large amounts of halogenated by-products to the environment:

- Haloforms ($CHBr_3$, $CHCl_3$,…)
- Haloacetic Acids (CH_2Br- COOH,….)
- Halophenols (2,4,6- Bromphenol,…)

-$CHBr_3$ is major from seawater
-$CHCl_3$ is major from fresh-water

mikromolar (10^{-6}) L^{-1}

→



Fuhlbrügge et al., 2015

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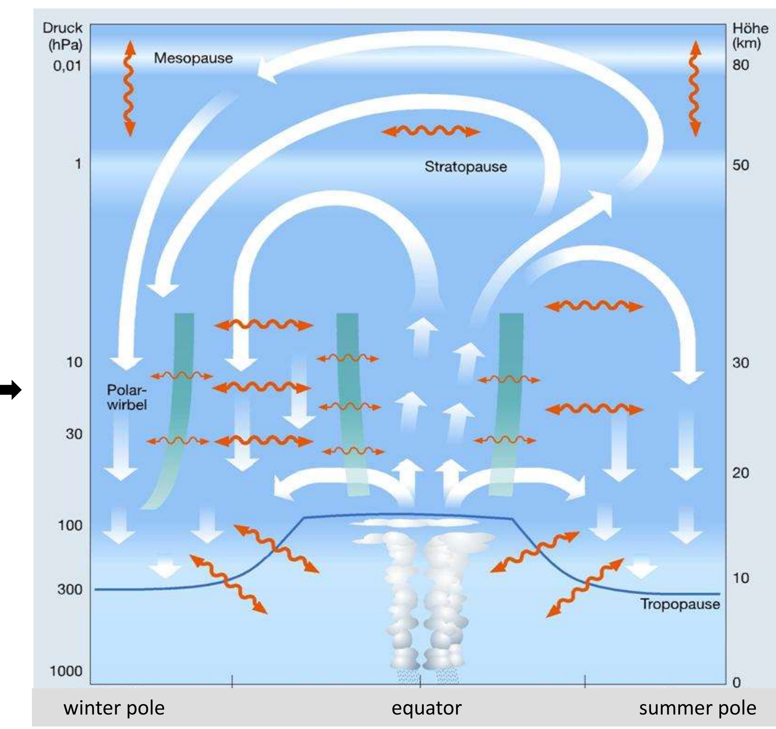


Engel et al., 2015

Natural halogenated volatile compounds (halocarbons) from the ocean, containing bromine (Br) and chlorine (Cl) contribute to ozone depletion in the stratosphere. Iodine (I) containing compounds are active in tropospheric chemistry and aerosol formation.

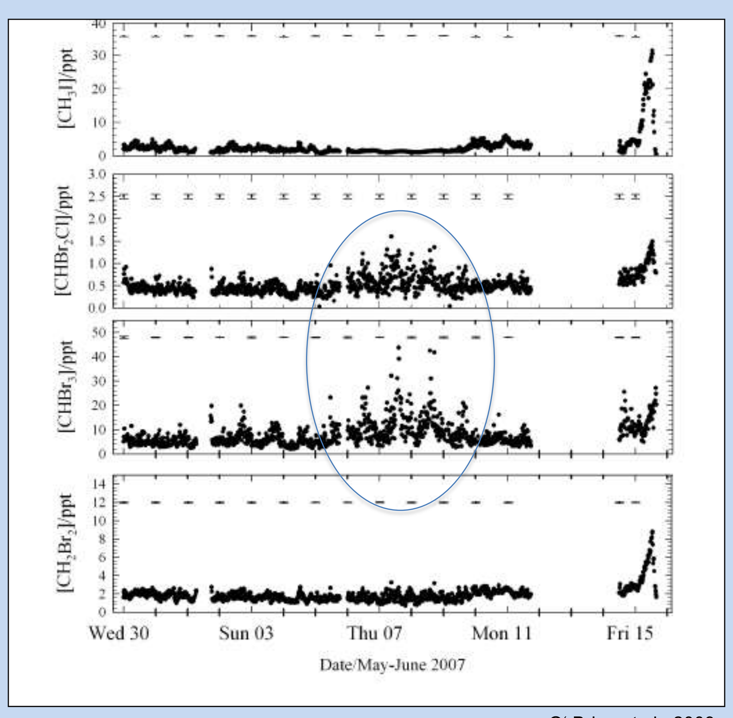
Coincidentally in water formed anthropogenic halocarbons emitted from the ocean raise the natural atmospheric processes.

Marine boundary layer (MABL) air can be transported horizontally near the surface over long distances, with almost no vertical transport, until it reaches areas of deep convection as entrance regions for the stratosphere.

Air from the tropical boundary layer reaches the stratosphere through deep convection and polar regions through the Brewer Dobson circulation (above).

Observations of halocarbons and air mass transport in the Macaronesian region

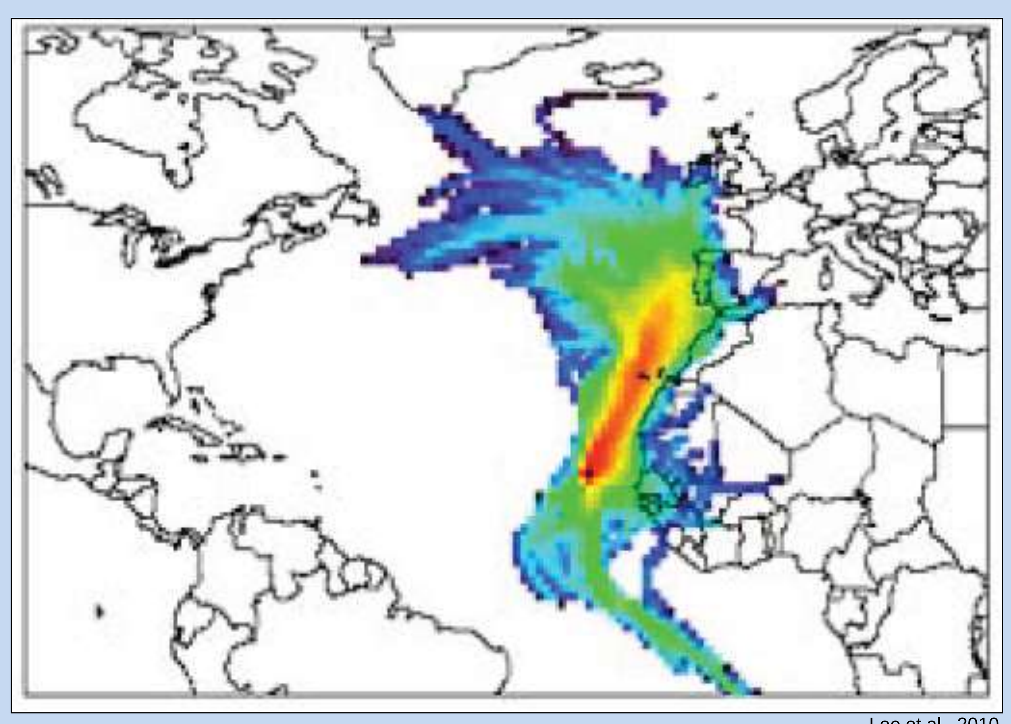
Halocarbons in air at the Cape Verde Atmospheric Observatory (CVAO)



O' Brien et al., 2009

Natural halocarbons are occasianally elevated at CVAO ($CHBr_3$ >30 pptv).

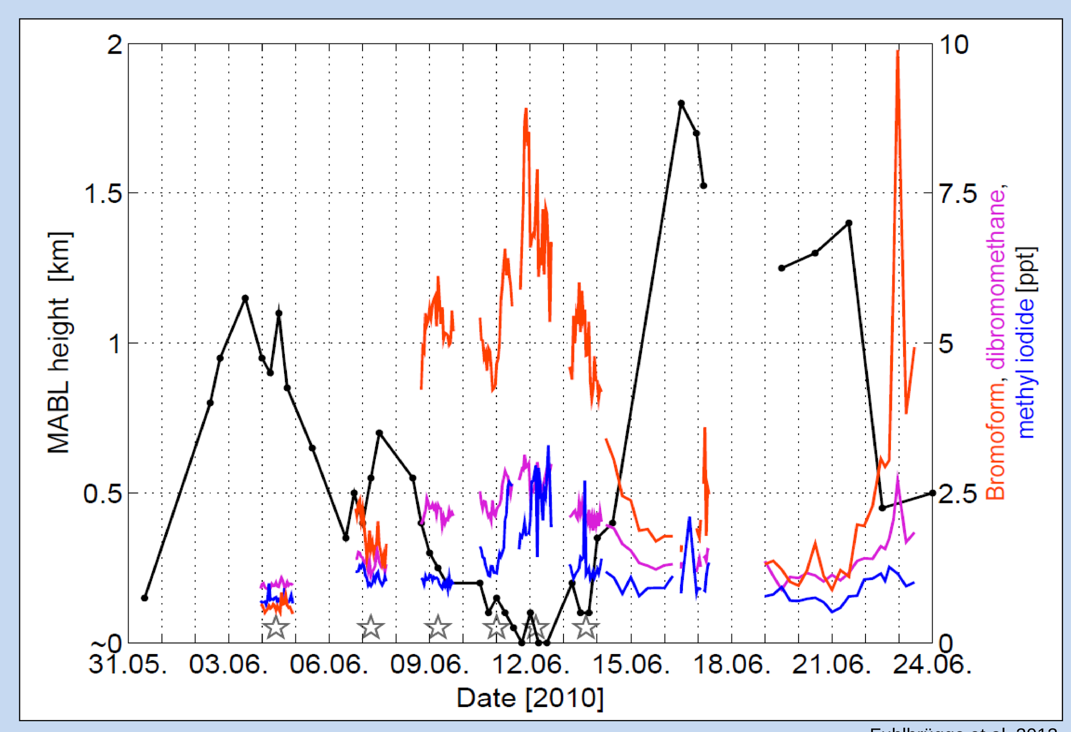
Air mass transport to the Cape Verde Atmospheric Observatory (CVAO)



Lee et al., 2010

5– day air mass back-trajectories show, that most of the air, reaching the CVAO in summer does not pass over the Mauritanian upwelling.

Halocarbons in air above the Mauritanian upwelling (RV Poseidon 399)



Fuhlbrügge et al. 2013

Natural halocarbons are elevated ($CHBr_3$ ~10 pptv) above the upwelling, when the marine boundary layer (MABL) heights are low.

Elevated atmospheric halocarbons, observed at CVAO in summer, do not origin from the Mauritanian upwelling, although this has often been suggested.

Which oceanic sources contribute to elevated halocarbon concentrations on Cape Verde?

The „Marine and Atmospheric Science Hot Spot“ around the Cap Verdean Archipelago, including the OSCM, CVAO, CVOO, INDP and GEOMAR, and elsewhere as PLOCAN on Las Palmas in the Macaronesian region offers an ideal opportunity to investigate and understand the contribution of natural and anthropogenic signatures, important for the local ocean, the region and the global atmosphere.

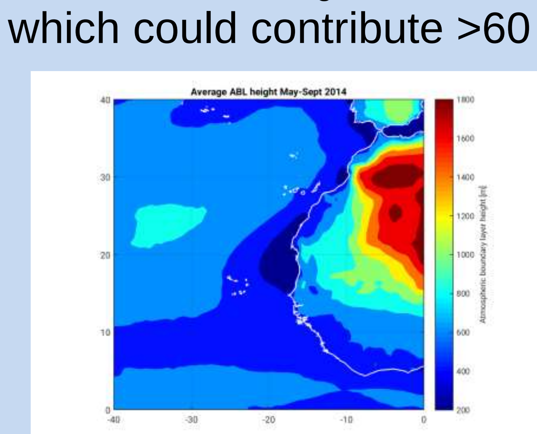
1) **Local natural and anthropogenic coastal sources!?**
Macroalgae are a likely source, but also other flora and fauna attached to coastal hard substrate may contribute? Desalination plants can emit $CHBr_3$ directly.

2) **Local natural and anthropogenic oceanic sources!?**
Sea water concentrations must be higher than >4nmol L^{-1} (observed in Miami).
Disinfected outflow of powerplants or waste water (>100 nmol L^{-1} observed). Marine biology may also contribute.

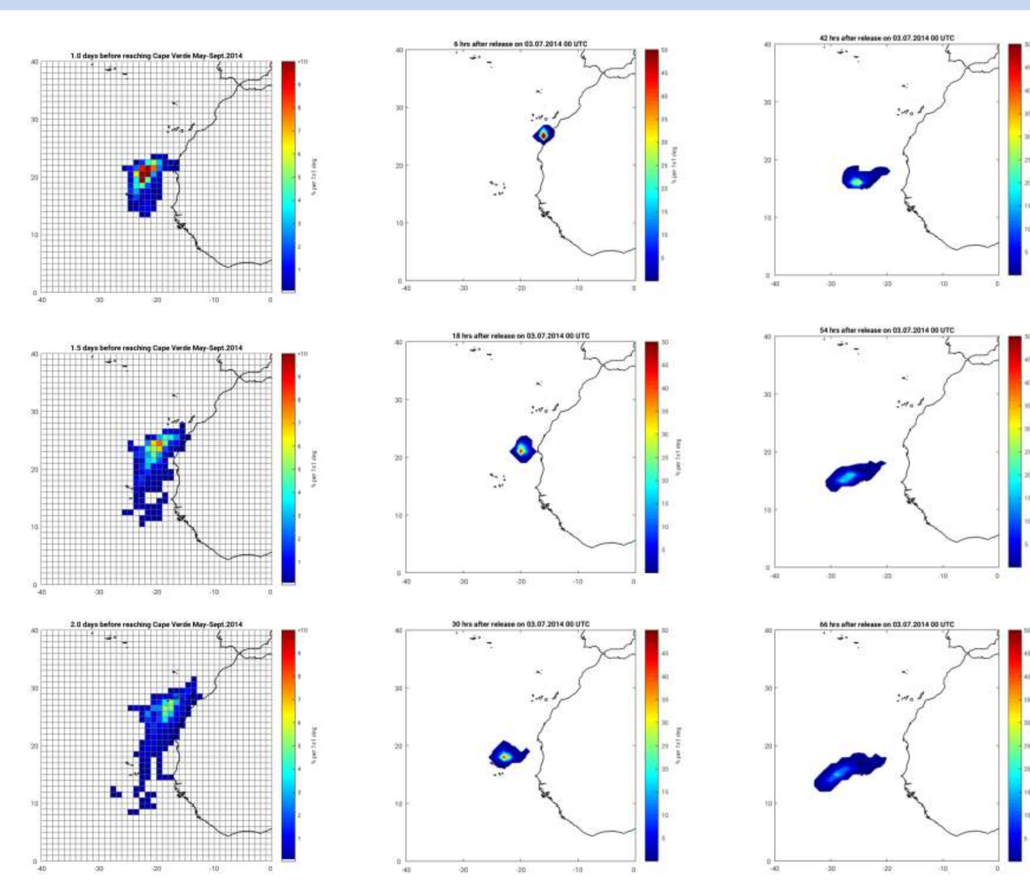
3) **Airmass transport from the Canary islands!?**

>10 % of the airmasses at CVAO in summer where in contact with the boundary layer air of the Canary Islands, >0.1 % with the Mauritanian upwelling.

Beaches of Las Palmas showed very high water concentrations of $CHBr_3$ >10 nmol L^{-1} (unknown origin), which could contribute >60 pptv to air.



Mean marine boundary layer height of the eastern tropical North Atlantic in summer (May-September 2014).



Mean backward trajectories (left, 20.000 started every 48h~1.5 Mio from May to September 2014) reveal that significant amounts of boundary layer air from the Canary Islands reach CVAO in two days.

Even undisturbed air masses with Canary Island characteristics reach CVAO in summer, as seen from forward trajectories (right).

Several sources are possible and need to be investigated in future projects, using novel technologies!

References

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